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(54) **FOOTWEAR SOLE WITH A MIDFOOT LATERAL EXTENSION TO INCREASE LATERAL STABILITY**

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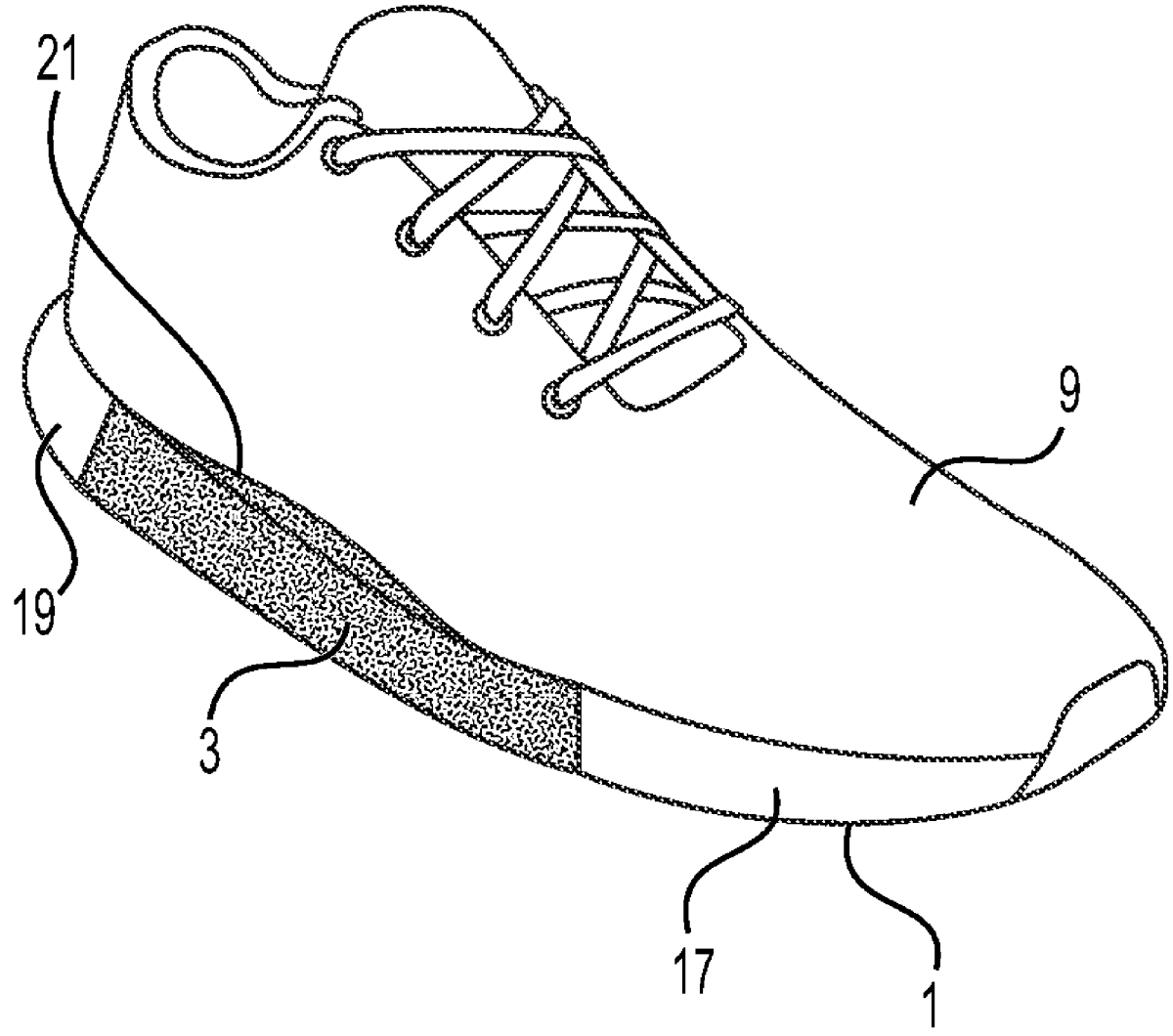
(52) **U.S. Cl.**

CPC *A43B 13/141* (2013.01); *A43B 13/181* (2013.01); *A43B 7/24* (2013.01)

(57) **ABSTRACT**

Footwear redesigned to include the midfoot lateral sole extension to eliminate the indention in a lateral midfoot portion of an existing design of a sole of the footwear and a revised design for an existing footwear sole that uses the midfoot lateral sole extension to eliminate the lateral midfoot indentation in the existing footwear sole. Also, a midfoot lateral sole extension for attachment to a footwear sole at an indention in a lateral midfoot portion of the footwear sole located between a lateral forefoot portion and a lateral heel portion of the footwear sole in order to fill the indentation. Also, disclosed is a method for improving lateral stability of an existing footwear sole having a lateral midfoot indentation by designing, fabricating and positioning the midfoot lateral sole extension on an existing footwear sole.



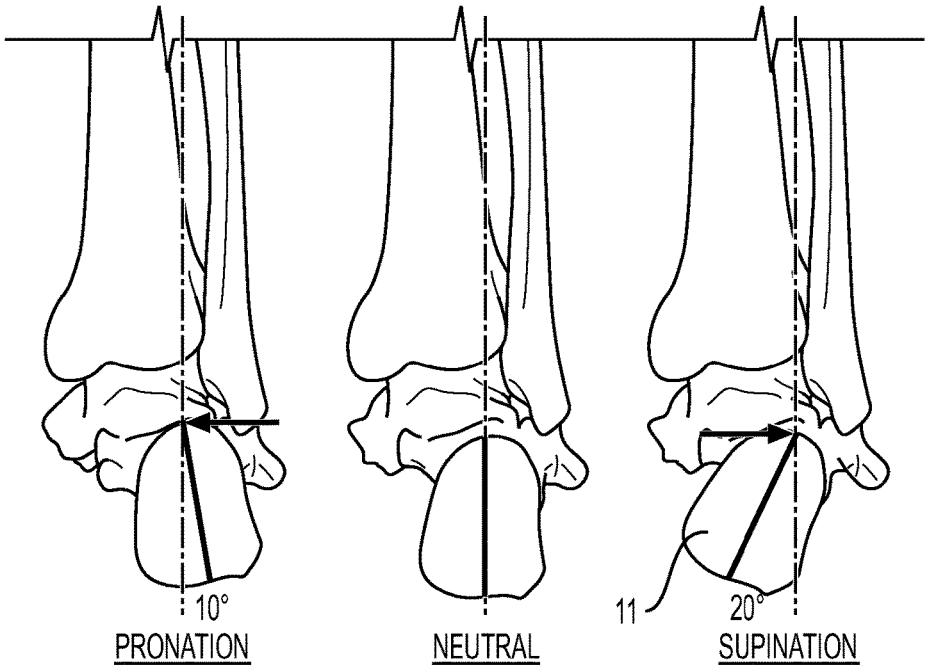


FIG. 1

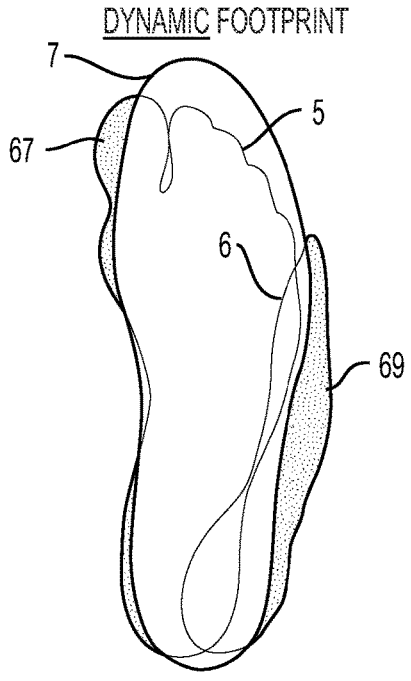


FIG. 2

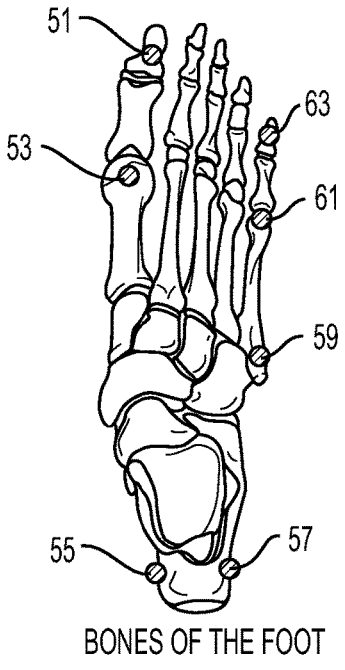


FIG. 3

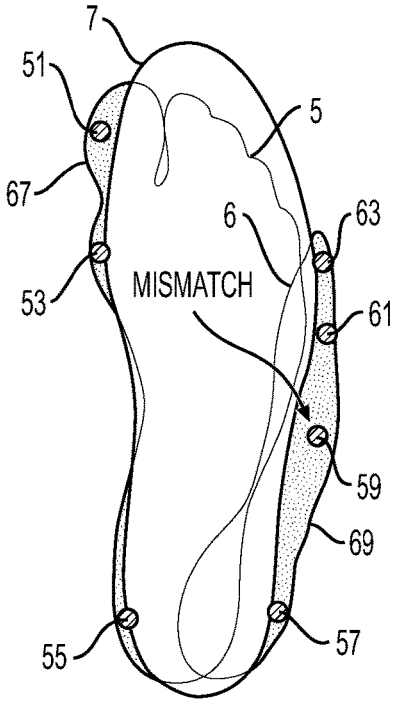


FIG. 4

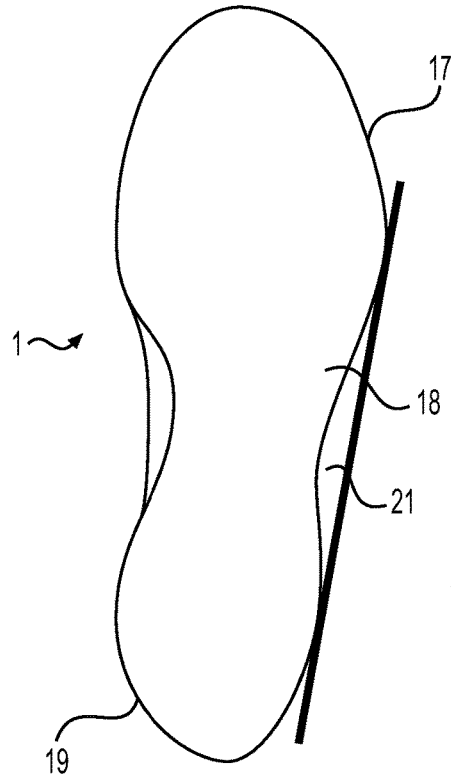


FIG. 5
(PRIOR ART)

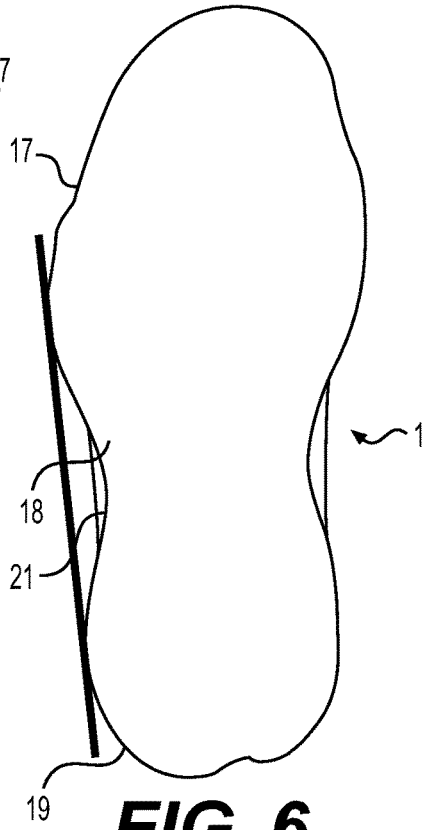


FIG. 6
(PRIOR ART)

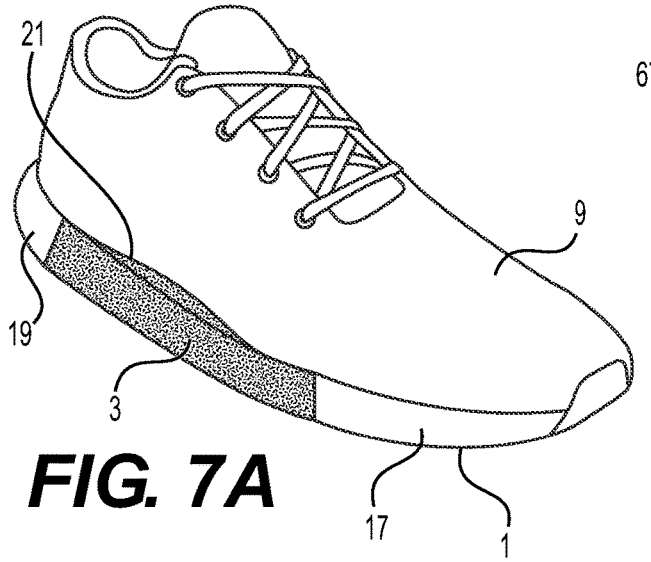


FIG. 7A

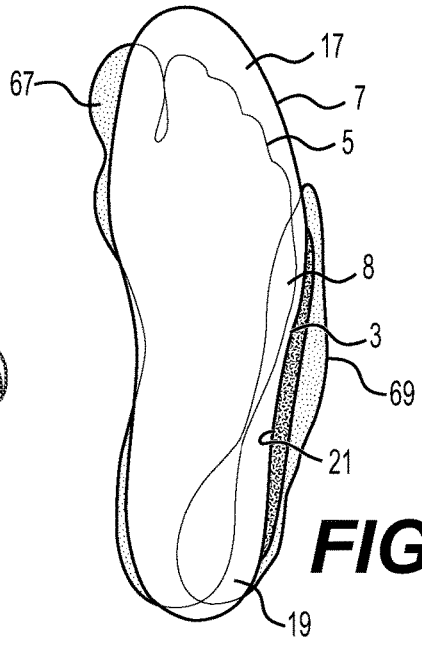


FIG. 7B

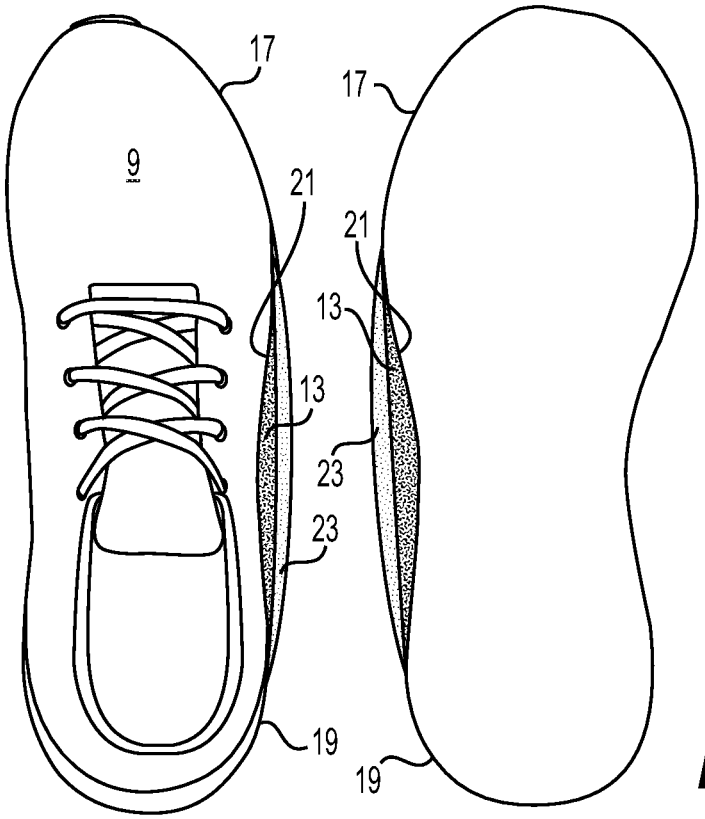


FIG. 8

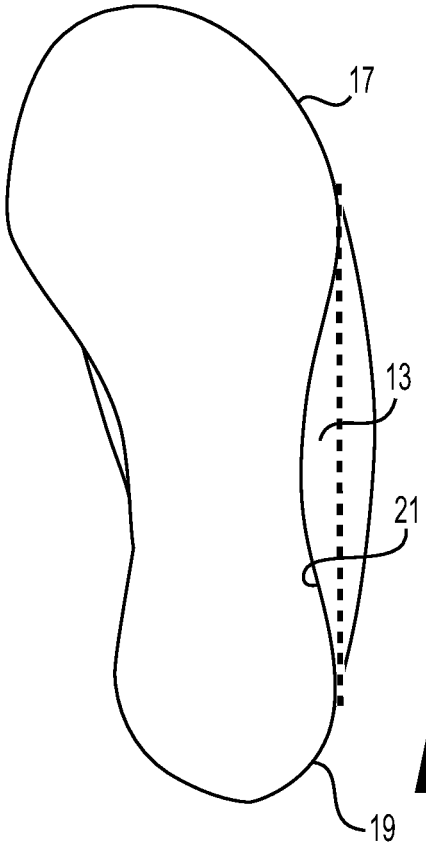


FIG. 9

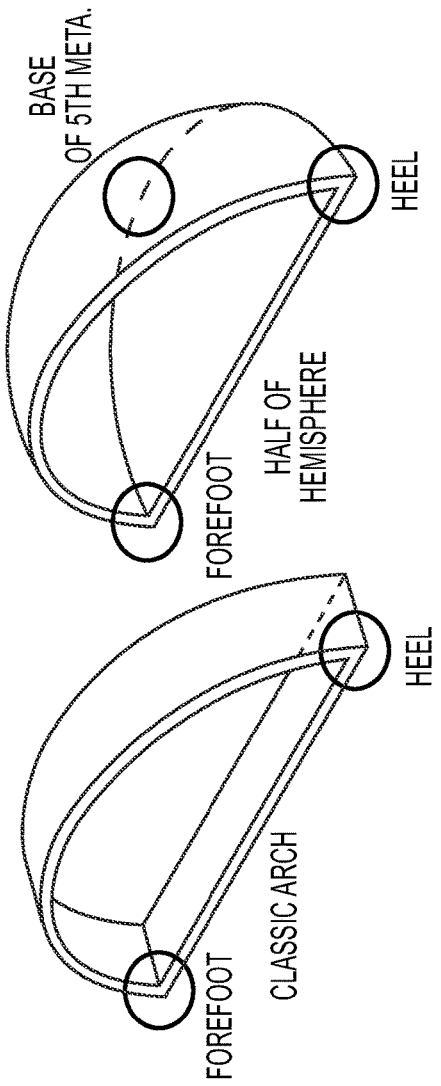


FIG. 11B

FIG. 11A

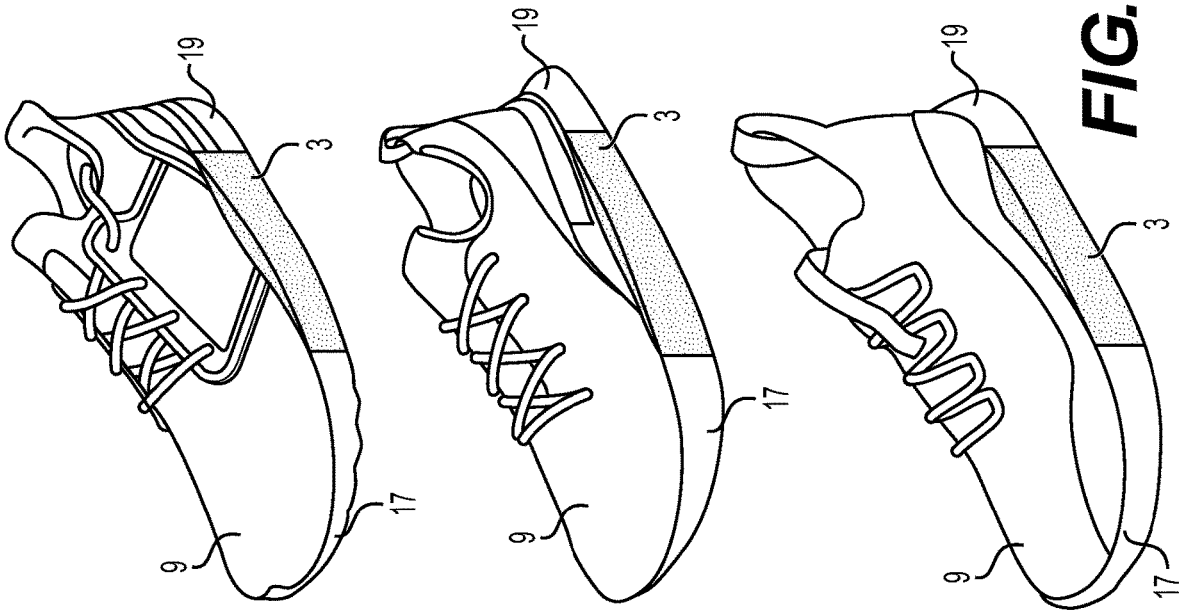


FIG. 10

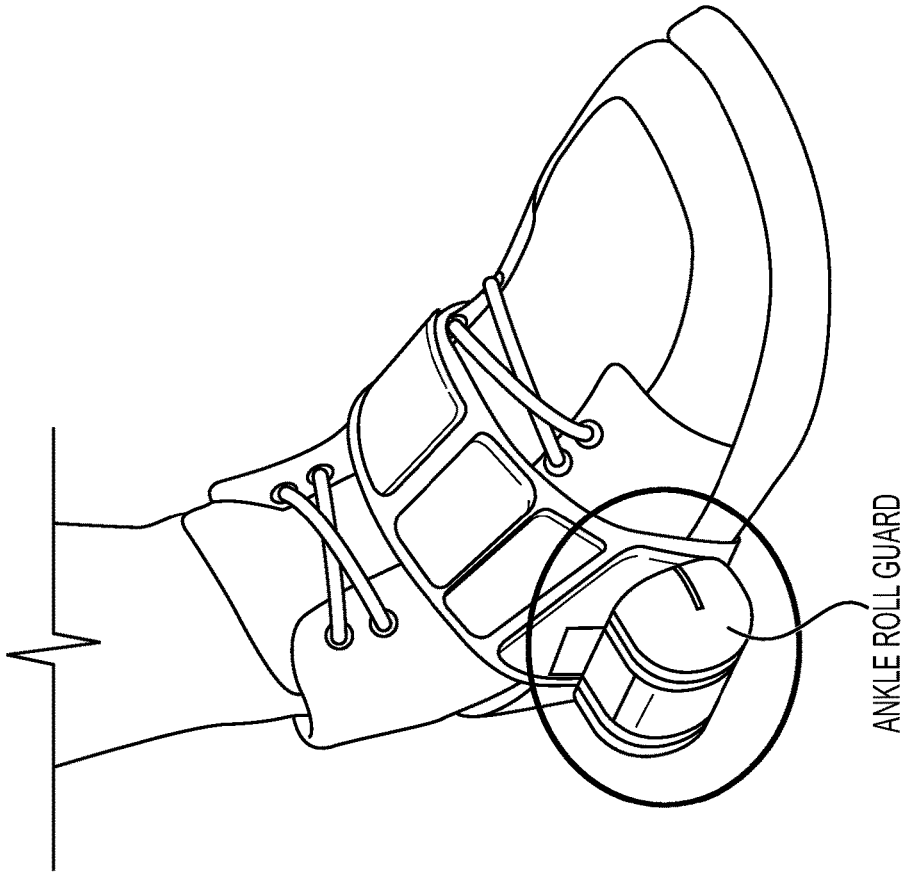


FIG. 13
(PRIOR ART)

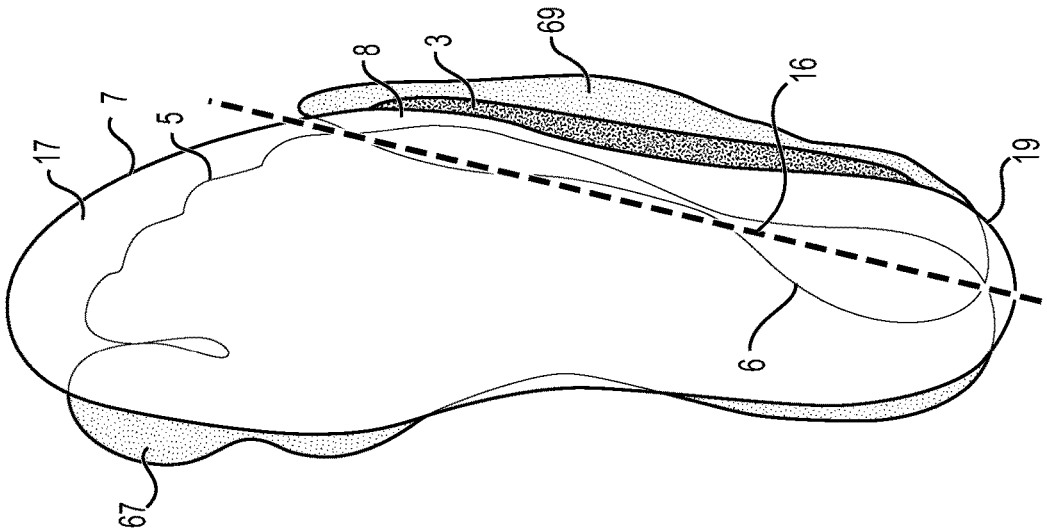


FIG. 12

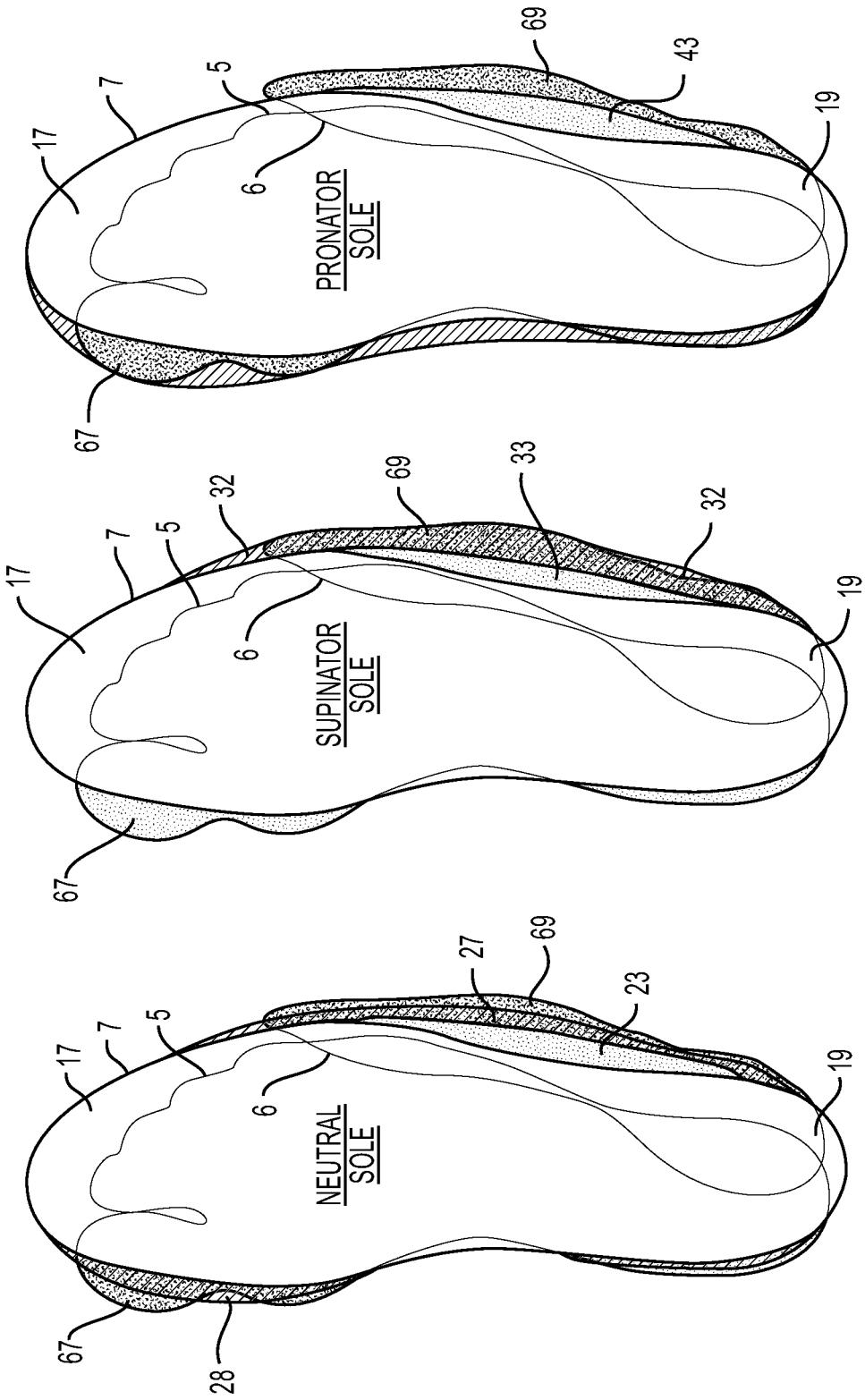


FIG. 14

FIG. 15

FIG. 16

FOOTWEAR SOLE WITH A MIDFOOT LATERAL EXTENSION TO INCREASE LATERAL STABILITY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional application No. 63/207,953, filed on Mar. 31, 2021, the disclosure of which is hereby incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to corrective action and structure to reduce or eliminate the instability trigger in conventional footwear soles by eliminating the indentation in the lateral midfoot portion of the footwear sole.

BACKGROUND OF THE INVENTION

[0003] The fundamental stability problem suffered by a large proportion of current athletic footwear is that the dynamic footprint that a foot makes on the ground through the full range of its lateral or side-to-side range of motion (R.O.M.) is much wider than the static footprint conventionally used to make footwear soles. The subtalar joint, located immediately below the ankle joint, allows the foot to move from a typical maximum internal motion of about 10° of pronation to a typical maximum external motion of about 20° of supination, as shown by the range of calcaneal eversion/inversion of the heel of the foot in FIG. **1**.

[0004] Although FIG. **1** represented conventional wisdom for many years, calcaneal eversion/inversion has since been measured more accurately. It has been found that the human subtalar joint has an average clinical range of supination motion of about 25°-30°, as measured in calcaneal inversion, as well as an average clinical range of pronation motion of about 5°-10°, as measured in calcaneal eversion. Sarrafian, S. and Kelikian, A., *Functional Anatomy of the Foot and Ankle*, p. 41 (2011) and Kelikian, A. (Ed.) *Sarrafian's Anatomy of the Foot and Ankle* (3rd Edition) (p. 543 and Table 10.5). Lippincott Williams & Wilkins.

[0005] This wide range of 30°-40° of subtalar joint pronation/supination motion means is that the foot tends to roll onto the inner or outer edge of the upper surface of the conventional footwear sole when the foot becomes substantially pronated or supinated during locomotion.

[0006] Perhaps more important is that when the foot becomes maximally pronated or supinated, the foot rolls off the surface of the footwear sole so that it is without direct structural support underneath it and therefore the foot rolls out of control, restrained only by the inadequate restraint of the footwear upper, thereby pivoting about a lever that is formed by the edge of the footwear sole.

[0007] The dynamic footprint of a typical shoe wearer shown in FIG. **2** is a combination of a maximum pronation footprint **5** with a part **67** of the pronation footprint unsupported by the structure of sole shown on the left side overlapped by a maximum supination footprint **6** with a part **69** of the supination footprint unsupported by the structure of the sole on the right side, which together show the full range of the foot on the ground that is allowed by the subtalar joint. Superimposed on the center of the dynamic footprint is an outline of a conventional shoe sole, which is too narrow to support the sides of the dynamic footprint.

[0008] The example of the dynamic footprint shown in FIG. **2** is a dynamic footprint of a typical shoe wearer whose pronated foot can essentially roll onto or entirely off the inside or medial edge of the upper surface of the footwear sole, restrained only by the footwear upper. More typical is the problem of rolling onto or entirely off the outside or lateral edge of the upper surface of the footwear sole. In either case, those unsupported sideways motions inherently create foot and ankle instability that can cause an ankle sprain or break, or a fall.

[0009] Importantly, the essential ground-contacting bone structures of the foot should be directly supported by the upper surface of the footwear sole throughout the full normal range of normal pronation and supination motion allowed by the subtalar joint, as seen in FIGS. **3**-**4**. This is basic structural architecture at its most fundamental level.

[0010] Just as a foundation is essential to support all the main structural elements of any building, a footwear sole must support the medial and lateral bones of the foot throughout their full range of motion. As seen in FIG. **3** located on the medial or inside of the foot are the calcaneus or heel bone, the head of the 1st metatarsal bone, and the 1st distal phalange (or big toe). Located on the lateral or outside of the foot are the lateral calcaneal tuberosity, the base and head of the 5th metatarsal bone, and the 5th distal phalange (or little toe). Shown in FIG. **3** are the 1st distal phalange **51**, the head of the 1st metatarsal **53**, the medial side of the calcaneus **55**, the lateral side of the calcenus **57**, the base of the 5th metatarsal **59**, the head of the 5th metatarsal **61**, and the 5th distal phalange **63**.

[0011] As seen in FIG. **4**, which shows a Dynamic Footprint superimposed on the outline of a conventional footwear sole, the largest mismatch between the footprint of the fully supinated foot and a conventional footwear sole is in the midfoot centered around the position of the base of the fifth metatarsal bone, located between the forefoot and heel portions (indicated by the arrow in FIG. **4**),

[0012] The conventional footwear sole has a needless indentation at the location of the lateral midfoot portion of the sole that allows the base of the fifth metatarsal to initiate instability of the foot relative to the footwear sole since it is this part of the wearer's foot which rolls the farthest off the lateral side of the footwear sole during extreme supination. This artificially creates critical stability problem. In effect, the structural indentation at the lateral midfoot portion of a conventional footwear sole functions as the trigger of lateral instability by initiating the unnatural tilting sequence of the footwear sole that quickly culminates in a lateral ankle sprain or break and usually also a fall.

[0013] This lateral midfoot indentation is a defect that has become a standard feature of nearly all conventional footwear soles and is a particular problem in modern athletic shoes which typically include deep lateral midfoot indentations and highly sculpted midsoles and outsoles. FIG. **5**, shows a bottom view of a sole of a modern running shoe illustrating the significant lateral midfoot indentation located next to the straight line. FIG. **6** shows a bottom view of a sole of a modern basketball shoe illustrating the significant lateral midfoot indentation located next to the straight line. Most classic everyday non-athletic shoes also include a lateral midfoot indentation that leaves the base of the 5th metatarsal inadequately supported.

[0014] Therefore, it is an object of the invention to undertake a relatively quick and easy corrective action to remove

this instability trigger in conventional footwear soles by eliminating the deep indentation in the lateral midfoot portion of the footwear sole, or even create an outward bulge in the sole at this location.

[0015] It is another objection of the invention is to undertake design modifications of conventional footwear soles with lateral midfoot indentations to reduce or eliminate these indentations.

[0016] These and other objections of the invention will be apparent from the summary and detailed description of the invention which follow.

SUMMARY OF THE INVENTION

[0017] In one embodiment the invention relates to footwear that is redesigned to include a midfoot lateral sole extension that eliminates an indention in a lateral midfoot portion of an existing design of a sole of the footwear, the lateral midfoot portion being located between a lateral forefoot portion and a lateral heel portion of the existing footwear sole. The footwear includes an indentation in the lateral midfoot portion of the footwear sole, an upper attached to the footwear sole, and a midfoot lateral sole extension. The midfoot lateral sole extension includes an upper surface, a lower surface, and an inner edge conforming to an outer surface of the indentation in the lateral midfoot portion of the footwear sole. The midfoot lateral sole extension is of of sufficient width to extend to at least a straight line between a peripheral lateral extent of a lateral forefoot portion of the footwear sole and a peripheral lateral extent of a lateral heel portion of the footwear sole.

[0018] In the foregoing embodiment the midfoot lateral sole extension may be an integral molded part of the footwear sole.

[0019] In each of the foregoing embodiments, an upper surface of the midfoot lateral sole extension may be located outside of the upper.

[0020] In each of the foregoing embodiments, the footwear may further include a flexibility axis located in the footwear sole proximate to the midfoot lateral sole extension and between the lateral forefoot portion of the footwear sole and the lateral heel portion of the footwear sole. The flexibility axis may be provided by a sipe, slit or material softness in the footwear sole.

[0021] In each of the foregoing embodiments, the midfoot lateral sole extension may extend to, but not beyond, the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole. Alternatively, in each of the foregoing embodiments, a portion of the midfoot lateral sole extension may form a bulge that extends beyond the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

[0022] In another embodiment, the invention relates to a revised design for an existing footwear sole that uses a midfoot lateral sole extension to eliminate a lateral midfoot indentation in the existing footwear sole. The revised design includes an indentation in the lateral midfoot portion of the footwear sole, an upper attached to the footwear sole, and the midfoot lateral sole extension.

[0023] In the foregoing embodiment, the design may be a digital design.

[0024] In each of the foregoing embodiments of the design, the upper surface of the midfoot lateral sole extension of the design may be located outside of the upper.

[0025] In yet another embodiment, the present invention relates to a midfoot lateral sole extension for attachment to a footwear sole at an indention in a lateral midfoot portion of the footwear sole. The lateral midfoot portion of the footwear sole is located between a lateral forefoot portion and a lateral heel portion of the footwear sole. The midfoot lateral sole extension includes an upper surface, a lower surface, an inner edge configured for filling the indentation in the lateral midfoot portion of the footwear sole, the midfoot lateral sole extension being of sufficient width to extend to at least a straight line between a peripheral extent of the lateral forefoot portion of the footwear sole and a peripheral extent of the lateral heel portion of the footwear sole when the midfoot lateral sole extension is positioned to fill the indentation in the lateral midfoot portion of the footwear sole.

[0026] In the foregoing embodiment, the midfoot lateral sole extension may further include means for attaching the midfoot lateral sole extension to the footwear sole.

[0027] In each of the foregoing embodiments of the midfoot lateral sole extension the midfoot lateral sole extension may extend to, but not beyond, the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole. Alternatively, in each of the foregoing embodiments of the midfoot lateral sole extension a portion of the midfoot lateral sole extension may form a bulge that extends beyond the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

[0028] In each of the foregoing embodiments of the midfoot lateral sole extension the upper surface of the midfoot lateral sole extension may be substantially flat.

[0029] In each of the foregoing embodiments of the midfoot lateral sole extension the lower surface of the midfoot lateral sole extension may be substantially flat.

[0030] In each of the foregoing embodiments of the midfoot lateral sole extension, the midfoot lateral sole extension may have a length extending from a rearward extent of the lateral forefoot portion of the footwear sole to a forward extent of the lateral heel portion of the footwear sole. Alternatively, In each of the foregoing embodiments of the midfoot lateral sole extension, the midsole lateral sole extension may have a length extending from a location in the lateral forefoot portion of the footwear sole to a forward extent of the lateral heel portion of the footwear sole.

[0031] In each of the foregoing embodiments of the midfoot lateral sole extension the width of the midfoot lateral sole extension may sufficient to extend the midfoot lateral sole extension beyond the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

[0032] In each of the foregoing embodiments of the midfoot lateral sole extension, the midfoot lateral sole extension may be configured as a separate component that is not an integral or molded part of the footwear sole.

[0033] A still further embodiment of the invention relates to a method for improving lateral stability of an existing

footwear sole having a lateral midfoot indentation by employing a midfoot lateral sole extension. The method includes steps of:

[0034] designing the footwear sole with the midfoot lateral sole extension by digitally mapping the indentation in the lateral midfoot portion of the existing footwear sole,

[0035] digitally designing the midfoot lateral sole extension to eliminate the digitally mapped indentation to provide a design of the midfoot lateral sole extension;

[0036] fabricating the midfoot lateral sole extension from the design of the midfoot lateral sole extension, and

[0037] positioning the midfoot lateral sole extension in the indentation in the lateral midfoot portion of the footwear sole to eliminate the indentation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] FIG. **1** is a view of the subtalar joint that allows the foot to move from a typical maximum internal motion of about 10° of pronation to a typical maximum external motion of about 20° of supination, showing the range of calcaneal eversion/inversion of the foot.

[0039] FIG. **2** is an example of the dynamic footprint, which is a combination of a maximal pronation footprint **5** and the maximal supination footprint **6**, of a typical intended wearer of the footwear whose pronated foot can essentially roll onto or entirely off the inside or outside edge of the upper surface of a conventional footwear sole.

[0040] FIG. **3** is an illustration of the essential ground-contacting bones of the foot.

[0041] FIG. **4** is FIG. **2**, also showing the location of the essential ground-contacting bones of the foot in the dynamic footprint relative to a conventional shoe sole.

[0042] FIG. **5**, shows a bottom view of a sole of an running shoe for a left foot illustrating the significant lateral midfoot indentation located next to the straight line.

[0043] FIG. **6** shows a bottom view of a sole of a basketball shoe for a right foot illustrating the significant lateral midfoot indentation located next to the straight line.

[0044] FIG. **7**A is a top perspective view of a shoe including an embodiment of a midfoot lateral sole extension in accordance with one embodiment of the invention.

[0045] FIG. **7**B is a top view of a dynamic footprint of an intended wearer's foot superimposed on the outline of the conventional footwear sole including a midfoot lateral sole extension in accordance with one embodiment of the invention.

[0046] FIG. **8** shows top and bottom views of a shoe with a sole including an embodiment of the invention, a relatively small or minimal extension **13** and midfoot lateral sole extension that projects further outward as a bulge **23**.

[0047] FIG. **9** shows the minimal midfoot lateral sole extension embodiment of the present invention that can be added to, or formed integrally with, a conventional footwear sole.

[0048] FIG. **10** shows three examples of shoes including the minimal midfoot lateral sole extension, namely, two running shoes and a basketball shoe.

[0049] FIG. **11**A shows a classic arch and FIG. **11** B shows a half of a hemisphere to illustrate, first, an outdated concept in FIG. **11**A and, second, a correct underlying structural concept of the longitudinal arch of the foot in FIG. **11**B.

[0050] FIG. **12** shows the embodiment of FIG. **7**B with a flexibility axis added to the shoe sole.

[0051] FIG. **13** shows a prior art external device configured as a lateral side extension that straps onto a conventional footwear sole.

[0052] FIG. **14** shows an embodiment of neutral footwear sole side extensions which are additional structures added to a bulging midfoot lateral sole extension that provide side extensions with improved neutral stability during pronation and supination.

[0053] FIG. **15** shows an embodiment of an increase in sole width positioned on the lateral side of the sole to form a lateral midfoot supinator sole extension.

[0054] FIG. **16** shows an embodiment of an increase in sole width positioned on the medial side of the sole to form a medial midfoot pronator sole extension.

DETAILED DESCRIPTION OF EMBODIMENTS

[0055] As shown in FIGS. **5-6**, the conventional footwear sole **1** includes a lateral forefoot portion **17**, a lateral heel portion **19** and a lateral midfoot portion **18** located between the lateral forefoot portion **17** and the lateral heel portion **19**. The lateral forefoot portion **17** of the footwear sole **1** is the portion that is located below the lateral part of the forefoot of an intended wearer of the footwear when the footwear is worn on the foot of the intended wearer. Similarly, the lateral heel portion **19** of the footwear sole **1** is the portion that is located below the lateral part of the heel of an intended wearer of the footwear when the footwear is worn on the foot of the intended wearer. The midfoot portion **18** of the footwear sole **1** is the portion of the footwear sole **1** located between the lateral forefoot portion **17** and the lateral heel portion **19** and the boundary between the lateral forefoot portion **17** and the midfoot portion **18** is typically about halfway between the base and head of the fifth metatarsal of the intended wearer's foot when positioned in the footwear on the footwear sole **1**.

[0056] In reference to the footwear sole **1** and the midfoot lateral sole extension **3** shown in FIGS. **7**A-**7**B, the length refers to the direction from the forefoot portion to the heel portion of the footwear sole **1**, the width refers to the direction from the lateral side to the medial side and the height refers to the thickness of the footwear sole **1** or midfoot lateral sole extension **3**.

[0057] Embodiments of the present invention are designed to eliminate the indentation **21** found on the midfoot lateral side of most conventional footwear soles **1**. An indentation **21** is defined as a recess in the lateral outer surface of the conventional footwear sole **1**. One way to determine if an indentation **21** is present is to draw a line from the lateral extent of the forefoot portion **17** of the footwear sole **1** to a lateral extent of the heel portion **19** of the footwear sole **1**, as shown in FIGS. **5-6**. If there is a space between this line and the lateral outer surface of the lateral midfoot portion **18** of the footwear sole **1**, then an indentation **21** is considered to be present.

[0058] The result of eliminating the indentation **21** on the midfoot lateral side of the conventional footwear sole **1** is shown by the midfoot lateral sole extension **3** in FIGS. **7**A-**7**B, shown here in a top perspective view (FIG. **7**A) and a top view (FIG. **7**B) as an additional feature added to a conventional footwear sole **1** such as the examples depicted in FIG. **10**. The outline of the conventional sole **7** of FIG. **7**B is shown superimposed on the maximal pronation footprint **5** and the maximal supination footprint **6** of the intended

wearer's foot. As seen in FIGS. **7**A-**7**B, the midfoot lateral sole extension **3** is located outside of the conventional footwear sole **1** and upper **9**.

[0059] The midfoot lateral sole extension **3** has an upper surface, a lower surface, and an inner edge that conforms to an outer surface of the indentation **21** in the lateral midfoot portion of the footwear sole **1**. The midfoot lateral sole extension **3** is of sufficient width to extend to at least a straight line between a peripheral lateral extent of a lateral forefoot portion **17** of the footwear sole **1** and a peripheral lateral extent of a lateral heel portion **19** of the footwear sole **1**. The midfoot lateral sole extension **3** may be an integral molded part of the footwear sole **1**.

[0060] The midfoot lateral sole extension **3** provides additional support for the base of the 5^{th} metatarsal bone of the intended wearer's foot in normal loadbearing and particularly during extreme supination **11**, as shown in the rightmost drawing of FIG. **1**, so that such excessive supination does not lead the foot sole of the intended wearer's foot off the conventional footwear sole **1**. In this embodiment, the rest of the conventional footwear sole **1** would remain unchanged in outward appearance and functionality.

[0061] Although this embodiment is only a partial measure in that it reduces, but does not eliminate the above-described problems with conventional footwear soles **1**. This embodiment is relatively easy to implement, and it can be made without the dangerous delay inherent in complete footwear redesign and attendant changes to manufacturing methods and equipment that would be required for more comprehensive corrections. The lateral stability of any conventional footwear design, especially classic ones with a relatively flat bottom sole, can be improved by simply eliminating the indentation **21** in the lateral midfoot portion **18** of the footwear sole **1**. As such, this is a straightforward way to immediately improve upon conventional, existing footwear designs.

[0062] The lateral indentation **21** is often deeper on the lower, ground-contacting surface of the conventional footwear sole **1** than on the upper, foot contacting surface, as seen in FIG. **8**. In such a case, the midfoot lateral sole extension **3** is structured to match the shape of this type of indentation **21**.

[0063] The midfoot lateral sole extension **3** can also be a relatively small or minimal extension **13**, as shown in one embodiment of FIG. **8**, or the midfoot lateral sole extension **3** can also project further outward as a bulge **23**, in another embodiment shown in FIG. **8**.

[0064] Preliminary development and testing indicated that eliminating the indentation **21**, even without projecting an outward bulge at the lateral midfoot portion **18** of the sole **1**—that is, only the minimal midfoot lateral sole extension **13** shown in FIG. **9** bordered by the straight dotted line—provides the greatest stability benefit in combination with the least effort and structural change of the footwear. Subjective evaluations supported the logical expectation that the minimal midfoot lateral sole extension **13** was an important change since it provided the missing direct structural support to the base of the 5^{th} metatarsal bone of the wearer's foot.

[0065] The meaningful improvement in lateral stability that results from this simple fix would have little effect on the look or aesthetics of the conventional footwear sole **1** (see the examples of two running shoes and a basketball shoe shown in FIG. **10**). These changes, however, will provide a measurable improvement by reducing the incidence of lateral ankle sprains, breaks, and falls. This is a worthwhile interim improvement, and relatively easy and inexpensive to implement since it does not otherwise significantly change the appearance or other functional performance of conventional footwear.

[0066] Although a precise level of effectiveness has not been determined, it seems likely that the minimal midfoot lateral sole extension **13** will significantly reduce ankle sprains, breaks and falls, perhaps by as much 25%. As such, this is a simple modification with an important potential safety benefit. Implementation of the minimal midfoot lateral sole extension **13** is likely to at least reduce the number and severity of lateral ankle sprains and falls during walking and standing, particularly among the elderly, as well as lowering the incidence and severity of those injuries to a much lesser degree for athletes.

[0067] Alternatively, the midfoot lateral sole extension **3** can also extend into the lateral forefoot portion **17** to thereby also support the head of the fifth metatarsal, which carries the peak load in the lateral ankle spraining position. Although the increased width of the sole **1** proximate to the head of the 5^{th} metatarsal is also very useful, it involves a more significant structural change, since it increases the overall width of the forefoot portion of the footwear sole **1**. Although this approach is useful as a quick fix, it preferable for this extra sole width in the forefoot portion of the sole **1** to be included within the footwear upper **9**, rather than outside of it.

[0068] An issue related to the midfoot lateral sole extension **3** is the conventional position of the rigid (or semi-rigid) shank in conventional footwear soles **1**, whether full length or the more conventional partial length, or midfoot torsion systems in running shoes that are used to support the midfoot, which is often not ground-contacting, between the lateral forefoot and lateral heel portions **17**, **19** of the sole **1** that are ground-contacting.

[0069] Midway between the heel and forefoot is the base of the 5^{th} metatarsal bone, the single bone structure located in the lateral midfoot area that supports the main longitudinal arch. The base of the 5^{th} metatarsal bone is located on the edge of a conventional sole at the center of the midfoot, a location that is precisely where the traditional lateral midfoot indentation **21** of the conventional sole **1** is located. That means the base of the 5^{th} metatarsal bone is poorly supported because of the traditional midfoot indentation **21** of conventional soles **1**, as shown in FIGS. **5**-**6**.

[0070] The footwear sole shank is traditionally located in the center of the midfoot, along the long axis of the sole, probably for the convenience of cobblers that made shoes centuries ago. However, the main longitudinal arch of the foot that connects the heel and forefoot is not just a simple medial arch between the heel and forefoot, depicted in FIG. **11**A. Rather, the main longitudinal arch has a much stronger and more complex three dimensional structure that looks schematically like a half of a dome or hemisphere with the base of the 5^{th} metatarsal bone forming a critical structural support. A comparison of an arch and the half of the hemisphere is shown in FIG. **11**B.

[0071] A key role of the base of the 5^{th} metatarsal bone is to anchor the main longitudinal arch of the foot. As mentioned above, the main longitudinal arch is generally misunderstood to be a simple arch with a classic uniform two-dimensional structure stretching from the heel to the forefoot of the foot. However, the main longitudinal arch is

actually more like a complex three-dimensional structure shaped like a half of a hemisphere as shown in FIG. **11**B, with the base of the 5^{th} metatarsal bone providing direct support in the middle of the arch. It is therefore essential that a stable footwear sole provide direct structural support to the base of the 5^{th} metatarsal bone to naturally support the foot's longitudinal arch, unlike conventional footwear soles **1** with their indentation **21** in the lateral midfoot portion **18**.

[0072] As a result, the midfoot lateral sole extension **3** should have the additional benefit of preventing or reducing Jones fracture injuries. The base of the 5^{th} metatarsal would be supported in a natural way by the midfoot lateral sole extension **3**, instead of being unsupported even when standing upright or walking, as well as during running or other athletics, including during extreme supination.

[0073] Since the base of the 5^{th} metatarsal is the key structural support of the main longitudinal arch, the shank should be moved from its traditional central location in the footwear sole to a more lateral location to provide direct support the base of the 5^{th} metatarsal. The location of the midfoot lateral sole extension **3** in the position of the lateral midfoot indentation **21** of the conventional footwear sole **1** shown in FIGS. **5-6** facilitates relocation of the shank to the proper lateral position.

[0074] In addition, the midfoot lateral sole extension **3** can be further improved in a limited way to look and function like the rounded sides of designs shown in the earlier U.S. patents incorporated by reference herein but limiting their extent to only a midfoot lateral sole extension **3**, to ensure that itis relatively easy to implement. Since the midfoot area is not typically a high wear area, the midfoot lateral sole extension **3** can be made solely of midsole material, without requiring use of more durable outsole material.

[0075] To uncouple the forefoot of the footwear sole from torquing over the heel in the lateral ankle spraining position of the foot, a flexibility axis **15** as shown in FIG. **12**, can be provided with deep sipes or relatively soft midsole material proximate to the midfoot lateral sole extension **3** and between the lateral forefoot portion **17** and the lateral heel portion **19**.

[0076] The midfoot lateral sole extension **3** is an add-on structure that is external to the footwear upper **9**, since that is a relatively easy way to implement a stability improvement in conventional footwear. To be maximally effective, the insole or sock liner of conventional footwear must also be similarly modified with structure that eliminates of the conventional indentation **21** in the insole or sock liner at least to the same extent as the midfoot lateral sole extension **3** eliminates the indentation **21** in the footwear sole **1**. In one embodiment, the insole or sock liner can be provided with an outwardly projecting structure that parallels the midfoot lateral sole extension **23** of the sole **1**. Alternatively, the thickness of the midfoot lateral sole extension **3** can be increased slightly to compensate for an absence of an insole or sock liner structure that parallels the structure of the midfoot lateral sole extension **3***t*.

[0077] The effectiveness of the extra time, effort and cost required to modify the design of a conventional footwear sole **1** with the midfoot lateral side extension **3** would be less than the effectiveness of using a better design that restores the full natural stability of the barefoot sole, like the barefoot-like footwear sole designs described in my issued U.S. patents incorporated by reference below. The midfoot lateral sole extension **3** is a stop-gap measure that somewhat reduces a stability problem, but does not restore the natural stability of the barefoot sole. However, the midfoot lateral sole extension **3** can be implemented quickly and easily at little cost or risk, so it provides a useful alternative to alter existing conventional footwear.

[0078] Existing footwear may be redesigned to include the midfoot lateral sole extension **3**. A revised design for an existing footwear sole uses the midfoot lateral sole extension to eliminate a lateral midfoot indentation in the existing footwear sole. Such a revised design of existing footwear may include the indentation in the lateral midfoot portion **18** of the existing footwear sole **1**, an upper **9** attached to the footwear sole **1**, and the midfoot lateral sole extension **3**. The revised design may be a digital design.

[0079] The redesign of existing footwear may be implemented by a method for improving lateral stability of an existing footwear sole having a lateral midfoot indentation that employs a midfoot lateral sole extension. Such a method may include steps of:

[0080] designing the footwear sole with the midfoot lateral sole extension by digitally mapping the indentation in the lateral midfoot portion of the existing footwear sole,

[0081] digitally designing the midfoot lateral sole extension to eliminate the digitally mapped indentation to provide a design of the midfoot lateral sole extension;

[0082] fabricating the midfoot lateral sole extension from the design of the midfoot lateral sole extension, and

[0083] positioning the midfoot lateral sole extension in the indentation in the lateral midfoot portion of the footwear sole to eliminate the indentation.

[0084] It is important to recognize the proven efficacy of a functionally similar commercially available external device configured as a lateral side extension that straps onto a conventional footwear sole **1**, as seen in FIG. **13**. This device is currently being marketed as the Armor1™ ankle roll guard (see www.anklerollguard.com). The ankle roll guard is worn on the lateral side of the footwear sole **1** proximate to the base of the 5^{th} metatarsal bone, like the midfoot lateral sole extension **3** of the present invention, although the ankle roll guard extends slightly toward the rear of the footwear sole **1** adjacent to the heel portion. The ankle roll guard is also designed to prevent lateral ankle sprains. However, unlike the midfoot lateral sole extension **3** of the present invention, the ankle roll guard is not integrated into the shoe sole itself but rather is a separate device that is strapped onto the shoe as shown in FIG. **13**.

[0085] Although the Armor1™ ankle roll guard design is structurally different than the midfoot lateral sole extension **3**, the ankle roll guard is similar enough to serve as a reasonable initial proof of concept for the functional effectiveness of reducing ankle sprains with the midfoot lateral sole extension **3** added onto the sole. Two peer reviewed studies published in 2020 indicate that " . . . of all the devices (ankle roll guard, brace, and tape), only the ankle roll guard appears to allow the user normal ankle motion (i.e. typical anatomical joint motion), while preventing excessive ankle inversion," this according to the senior researcher from Boise State University. Both studies are available at anklerollguard.com under Testing & Information. See also Ihmels, W., Seymore, K., & Brown, T., "Effectiveness of Novel Ankle Prophylactic Compared With Lace-Up Brace or Tape," *Journal of Sport Rehabilitation*, (Jan. 2, 2020), 29:5, 693-696 and Ihmels, W., Seymore, K., & Brown, T., "Effect of Sex and Ankle Brace Design on Knee Biome-

chanics During a Single-Leg Cut," *The American Journal of Sports Medicine,* 48:6, 1496-1504 (2020).

[0086] The midfoot lateral sole extension **3** can likely be made more functionally effective by enlarging it into a structure more like that of the Armor1™ ankle roll guard, but attached to or fully integrated into the structure of the shoe sole, instead of being a strapped-on separate component. The integrated look of the midfoot lateral sole extension **3** of the present invention as an integral part of the shoe sole would also be more aesthetically appealing and more durable than the ankle roll guard. Thus, one means for attachment of the midfoot lateral sole extension **3** to the footwear sole **1** is to form the midfoot lateral sole extension **3** as an integral or molded part of the footwear sole **1**.

[0087] For example, since the strap of the ankle roll guard must pass under the shoe sole this strap is subject to severe wear in use and thus adversely impacts the durability of the device, potentially requiring replacement straps from time-to-time. Also, the strap under the shoe sole will alter the traction characteristics of the sole. In addition, the ankle roll guard is not easy to put on and take off, particularly for elderly or injured users. Further, the ankle roll guard must be strapped on very tightly to ensure that it is effective, creating another difficulty for the user, particularly taking into consideration the significant variations in shoe designs that may be encountered in use of the ankle roll guard.

[0088] A midfoot lateral sole extension **3** can be attached to the footwear sole **1** by gluing or fusing a lateral side extension of midsole material onto the footwear sole **1** at the location of the indentation **21** in the conventional sole **1**. A belt sander can be used to remove excess material from the midfoot lateral sole extension **3** in the lateral forefoot and lateral heel portions **17**, **19** to cause the extension **3** to blend into the existing sides of the footwear sole **1**, with the remaining structure of the midfoot lateral sole extension **3** centered about the head of the 5^{th} metatarsal bone of the intended wearer. Alternatively, the midfoot lateral sole extension **3** can be positioned and structured so that it bulges outward proximate to both the base and the head of the 5^{th} metatarsal bone and/or the heel bone of the intended wearer.

[0089] This crude method for implementing the midfoot lateral sole extension **3** points the way to a easiest possible industry design and manufacturing approach that can be applied immediately. A separate midsole piece can be structured as a midfoot lateral sole extension **3** to fit precisely into the lateral indentation **21** of a conventional footwear sole **1**. This structure functions as a plug to fill the gap created by the lateral indentation **21**.

[0090] The midfoot lateral sole extension **3** can be molded as a separate piece to attach to specific size(s) of specific or general model(s) of a footwear sole **1**. Alternatively, this component can be made from material attached to the indentation **21** and then shaped to fit the indentation **21** as precisely as desired, once it is in position. The midfoot lateral sole extension **3** can be securely and permanently or temporarily attached with glue or other conventional attachment means known in the art, other than straps that encircle the shoe sole as in the ankle roll guard or equivalents thereof, onto an otherwise conventional footwear sole **1** to make the footwear sole **1** significantly safer.

[0091] The separate midfoot lateral sole extension **3** can also extend into the lateral forefoot portion **17** proximate to the position of the head of the 5^{th} metatarsal or distal phalanges of an intended wearer; or into the lateral heel portion **19** proximate to the position of the intended wearer's calcaneus; or proximate to both the lateral forefoot and lateral heel portions **17**, **19**.

[0092] The foot is tilted outward in a maximally supinated position when ankle spraining occurs. It seems logical, therefore, to provide an axis of flexibility **15** in the conventional footwear sole **1** so that the portion of the footwear sole **1** under the maximally supinated foot can remain flat to support the foot sole as neutrally as if the foot were bare. The flexibility axis **15** should be located proximate to the area where the maximal supination footprint **6** and the maximal pronation footprint **5** overlap onto the same part of the footwear sole **1**, as shown in FIG. **12**.

[0093] An alternative example of the flexibility axis **15** is a straight axis located next to the maximal supination footprint **6**. A further alternative embodiment employs a curved flexibility axis **15** located in the area in which the two footprints overlap. The curvature of the curved flexibility axis could be parallel or substantially parallel to the shape of the maximal supination footprint **6** or the shape of the maximal pronation footprint **5**.

[0094] To avoid forcing the supinated foot to roll outward on the footwear sole **1**, the flexibility axis **15** also can be positioned to extend in a medial direction. The flexibility axis **15** can be formed from midsole and/or outer sole material with increased flexibility relative to the footwear sole **1**, that results from a lower relative density, as measured on the Asker C durometer scale, for example. Alternatively, the flexibility axis can provide structural flexibility created by using less material, such as in the outsole/midsole tread pattern and/or by providing a channel and/or sipe in the outsole/midsole. The Nike Free™ model soles are an example of the use of such sipes in the form of slits or channels originating in the bottom surface of the footwear sole **1**.

[0095] In addition, as shown in FIGS. **1** and **5-6**, the relative motion of the barefoot sole on the footwear sole **1** during maximum supination is much greater in the lateral forefoot portion **17**, particularly, and also in the midfoot, compared to the lateral heel portion **19**. Also, during extreme supination, the calcaneus of the barefoot tilts substantially, but the heel of the foot remains flattened by deforming, while the midfoot and forefoot become tilted outwardly. The midfoot and forefoot also flatten somewhat during extreme supination by deforming only under the base and head of the fifth metatarsal bone. Consequently, the flexibility axis **15** can be located only in the midfoot and lateral forefoot portion **17** or have greater flexibility provided in those areas by the differential use of material or structural flexibility using channels or sipes.

[0096] Also, since it can exclude the lateral heel portion **19**, the flexibility axis **15** can be located more laterally, into the position of the shank described above. The functional goal would be to enable the footwear sole forefoot portion and midfoot to tilt naturally like the barefoot in the extreme supination position without forcing the footwear sole heel portion to also tilt, since the footwear sole heel portion should remain flat to parallel the barefoot heel's continuous flattening throughout the full range of motion of the tilting of the calcaneus, enabled by the subtalar joint.

[0097] In the lateral ankle spraining position in a conventional footwear sole **1**, the forefoot unnaturally torques the footwear heel portion over to the side, unlike the tilted barefoot in the same position. Therefore, another embodi-

ment that employs a similar approach is to create a midfoot flexibility zone **25** to uncouple the tilted forefoot portion from the heel portion, so that the heel portion can remain flat. This can be accomplished, for example, by providing deep Nike Free™-type sipes or relatively flexible sole and midsole material in most or nearly all of the sole's midfoot area. Only the support area under the base of the fifth metatarsal needs to be as firm as the lateral forefoot and lateral heel portions **17**, **19**.

[0098] It is possible to design a conventional footwear sole with reasonable midfoot lateral sole extensions **3** that are not too extreme, but still provide better lateral stability in excessive pronation and supination. As shown in FIG. **14**, in the neutral footwear sole extension additional structures **27**, **28** are added to a bulging midfoot lateral sole extension **23**, those less extreme side extensions still provide much improved neutral stability during pronation and supination. This neutral design might however be more useful for an everyday shoe for walking and standing and is less suitable for athletics.

[0099] Barefoot-like footwear soles such as those described in the U.S. patents incorporated by reference herein, need to be as wide as the dynamic footprint of a wearer's foot sole, but also should be structured as extensions of the wearer's curved foot sole, not flat sections of the ground. Therefore, the extra wide sides of the natural footwear sole should be rounded, wrapping up around the curved sides of the wearer's naturally rounded foot sole. In addition, to avoid a destabilizing rocking-chair effect caused by the rounded sides of a natural footwear sole, it needs to be sufficiently flexible to flatten by deforming under the body weight load of the wearer, when the wearer's foot rolls sideways into pronation or supination, particularly if that sideways motion is extreme. Otherwise, an unstable rocking chair effect would be unnaturally created in sideways supination or pronation.

[0100] Also, it is optimal for the sole of a natural footwear sole to be fully rounded directly underneath the rounded sole of the wearer's foot, instead of flat, and, in particular, fully rounded under the wearer's rounded heel, so that the footwear sole flattens the same way the foot sole flattens, especially in the rounded heel area.

[0101] Finally, the natural footwear sole must have uniform thickness in frontal plane cross-sections directly underneath the wide dynamic footprint of the intended wearer. If the footwear sole is uniformly thick only under the conventional static footprint, as is typical for conventional footwear soles, during extreme pronation or supination the wearer's foot will roll unstably down the tapered sole side area that has the reduced thickness. Further details are provided in the issued U.S. patents incorporated by reference herein.

[0102] To provide a wider conventional footwear sole for an intended wearer who would be characterized in conventional terms as a "supinator", the increase in sole width **32** can be positioned on the lateral side that is added to the lateral midfoot supinator sole extension **33** as shown in FIG. **15**.

[0103] Like in the midfoot lateral sole extension **3**, the lateral midfoot supinator sole extension **33** can be located outside of the footwear upper **9**. Alternatively, the additional lateral width of the lateral midfoot supinator sole extension **33** can be partially or fully located within the footwear upper **9**, with the remainder of the lateral midfoot supinator sole extension **33** remaining outside the upper.

[0104] The resulting wider footwear sole would have the overall shape that is conventionally characterized as a curved last shoe. The result is a wider, more stable footwear sole that is "tuned" for intended wearers who are supinators, but that is still substantially less wide than a footwear sole that is as wide as the dynamic footprint shown in FIG. **2**.

[0105] The effectiveness of taking the extra time and trouble to modify the design of a conventional footwear sole **1** would be much less than the effectiveness of using the midfoot lateral sole extension **33** for a supinator to create a new and much better design that restores the full natural stability of the barefoot sole, by incorporating it into the barefoot-like footwear sole designs described above and in the issued U.S. patents, which are incorporated by reference herein.

[0106] To provide a wider conventional footwear sole for an intended wearer who would be characterized in conventional terms as a "pronator", the increase in medial sole width **42** can be positioned on the medial side of the footwear sole **1**, as shown in FIG. **16**. Similar to the midfoot lateral sole extension **3**, the medial midfoot pronator sole extension **43** would be located outside of the footwear upper **9**. Alternatively, the additional medial width **42** can be partially or fully located within the footwear upper **9**, with the medial midfoot pronator sole extension **43** remaining outside the footwear upper **9**.

[0107] The resulting wider footwear sole for the pronator would have the overall shape that is characterized as a straight last shoe. In this embodiment, the midfoot lateral sole extension **3** or **33** located on the lateral side of the footwear sole **1** may be retained. The result is a wider, more stable footwear sole for pronators, but that is still substantially less wide than a footwear sole having the width of the dynamic footprint shown in FIG. **2**.

[0108] Again, the effectiveness of taking the extra time and trouble to modify the design of a conventional footwear sole would be much less than the effectiveness of using the medial side pronator sole extension **43** to create a new and much better design that restores the full natural stability of the barefoot sole, by incorporating it into the barefoot-like footwear sole designs described above and in the issued U.S. patents that are incorporated by reference herein

[0109] The applicant's other footwear U.S. Pat. Nos. 4,989,349; 5,317,819; 5,544,429; 5,909,948; 6,115,941; 6,115,945; 6,163,982; 6,308,439; 6,314,662; 6,295,744; 6,360,453; 6,487,795; 6,584,706; 6,591,519; 6,609,312; 6,629,376; 6,662,470; 6,675,498; 6,675,499; 6,708,424; 6,729,046; 6,748,674; 6,763,616; 6,789,331; 6,810,606; 6,877,254; 6,918,197; 7,010,869; 7,082,697; 7,093,379; 7,127,834; 7,168,185; 7,174,658; 7,234,249; 7,287,341; 7,334,356; 7,546,699; and 7,647,710; are hereby incorporated by reference herein in their entirety into this application for completeness of disclosure of the applicant's novel and useful combination of one or more of any of the features or components of any of the figures of this application with one or more of any of the features of any one or more of the preceding applicant's patents listed above in this paragraph.

1. Footwear that is redesigned to include a midfoot lateral sole extension that eliminates an indention in a lateral midfoot portion of an existing design of a sole of the footwear, the lateral midfoot portion being located between a lateral forefoot portion and a lateral heel portion of the existing footwear sole, the footwear comprising:

the indentation in the lateral midfoot portion of the footwear sole,
an upper attached to the footwear sole, and
the midfoot lateral sole extension,
the midfoot lateral sole extension comprising:
an upper surface,
a lower surface, and
an inner edge conforming to an outer surface of the indentation in the lateral midfoot portion of the footwear sole,
the midfoot lateral sole extension being of sufficient width to extend to at least a straight line between a peripheral lateral extent of a lateral forefoot portion of the footwear sole and a peripheral lateral extent of a lateral heel portion of the footwear sole.

2. The footwear of claim **1**, wherein the midfoot lateral sole extension is an integral molded part of the footwear sole.

3. The footwear of claim **1**, wherein an upper surface of the midfoot lateral sole extension is located outside of the upper.

4. The footwear of claim **1**, further comprising a flexibility axis located in the footwear sole proximate to the midfoot lateral sole extension and between the lateral forefoot portion of the footwear sole and the lateral heel portion of the footwear sole.

5. The footwear sole of claim **1**, wherein the flexibility axis is provided by a sipe, slit or material softness in the footwear sole.

6. The footwear sole of claim **1**, wherein the midfoot lateral sole extension extends to, but not beyond, the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

7. The footwear sole of claim **1**, wherein a portion of the midfoot lateral sole extension forms a bulge that extends beyond the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

8. A revised design for an existing footwear sole that uses a midfoot lateral sole extension to eliminate a lateral midfoot indentation in the existing footwear sole, the revised design comprising:
the indentation in the lateral midfoot portion of the existing footwear sole,
an upper attached to the footwear sole, and
the midfoot lateral sole extension,
the midfoot lateral sole extension comprising:
an upper surface,
a lower surface, and
an inner edge conforming to an outer surface of the indentation in the lateral midfoot portion of the footwear sole, and
the midfoot lateral sole extension being of sufficient width to extend to at least a straight line between a peripheral lateral extent of a lateral forefoot portion of the footwear sole and a peripheral lateral extent of a lateral heel portion of the footwear sole.

9. The design of claim **8**, wherein the design is a digital design.

10. The design of claim **8**, wherein the upper surface of the midfoot lateral sole extension of the design is located outside of the upper.

11. A midfoot lateral sole extension for attachment to a footwear sole at an indention in a lateral midfoot portion of the footwear sole, the lateral midfoot portion of the footwear sole being located between a lateral forefoot portion and a lateral heel portion of the footwear sole, the midfoot lateral sole extension comprising:
an upper surface, a lower surface, an inner edge configured for filling the indentation in the lateral midfoot portion of the footwear sole, the midfoot lateral sole extension being of sufficient width to extend to at least a straight line between a peripheral extent of the lateral forefoot portion of the footwear sole and a peripheral extent of the lateral heel portion of the footwear sole when the midfoot lateral sole extension is positioned to fill the indentation in the lateral midfoot portion of the footwear sole.

12. The midfoot lateral sole extension of claim **11**, further comprising means for attaching the midfoot lateral sole extension to the footwear sole.

13. The midfoot lateral sole extension of claim **11**, wherein the midfoot lateral sole extension extends to, but not beyond, the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

14. The midfoot lateral sole extension of claim **11**, wherein a portion of the midfoot lateral sole extension forms a bulge that extends beyond the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

15. The midfoot lateral sole extension as claimed in claim **11**, wherein the upper surface of the midfoot lateral sole extension is substantially flat.

16. The midfoot lateral sole extension as claimed in claim **11**, wherein the lower surface of the midfoot lateral sole extension is substantially flat.

17. The midfoot lateral sole extension of claim **11**, having a length extending from a rearward extent of the lateral forefoot portion of the footwear sole to a forward extent of the lateral heel portion of the footwear sole.

18. The midfoot lateral sole extension of claim **11**, having a length extending from a location in the lateral forefoot portion of the footwear sole to a forward extent of the lateral heel portion of the footwear sole.

19. The midfoot lateral sole extension of claim **11**, wherein the width of the midfoot lateral sole extension is sufficient to extend the midfoot lateral sole extension beyond the straight line between the peripheral extent of the lateral forefoot portion of the footwear sole and the peripheral extent of the lateral heel portion of the footwear sole.

20. The midfoot lateral sole extension of claim **11**, is configured as a separate component that is not an integral or molded part of the footwear sole.

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